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A direct method to extract strain energy release rates using XFEM and Irwin's integral

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ABSTRACT

An analytical formulation based on Irwin's integral and combined with the extended finite element method is proposed to extract mixed-mode components of strain energy release rates in linear elastic fracture mechanics. High-order crack tip enrichment functions in XFEM allow for evaluation of integral quantities in closed form, resulting in a simple, accurate, and efficient method. Hence, SIFs can directly be obtained upon solution of the XFEM discrete system. Several benchmark examples on pure and mixed mode problems are studied, investigating the effects of the order of the enrichment, mesh refinement, and the length of crack extension. The numerical results show that high accuracy can be achieved on structured as well as unstructured meshes. Examples of a crack approaching a hole and two cracks approaching each other are also investigated. The latter illustrate the advantage of this method over a J-integral class of methods, as SIFs can still be calculated when cracks are in close proximity and no remeshing is required. Hence potentially this method can address crack coalescence and branching more rigorously.